

Comparison of closed and open reduction in developmental hip dysplasia regarding leg inequality

Leg length discrepancy in developmental hip dysplasia

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Abstract

Aim: The aim of our study is to identify and compare the characteristics of leg length discrepancy in unilateral developmental hip dysplasia patients treated with closed reduction and medial open reduction. **Material and Method:** Clinical and radiographic data of 108 patients with unilateral developmental hip dysplasia were evaluated retrospectively. Thus, 31 patients (42.5%) were included in closed reduction group (Group 1), and 42 patients (57.5%) were included in the medial open reduction group (Group 2). The mean age of the patients at the time of the treatment in Group 1 was 9.9 ± 4.5 months, and the mean age of the patients in Group 2 was 12.8 ± 5.5 months. Radiography scans were obtained by computed radiography to assess radiological parameters of patients during the final examination. **Results:** The results showed that both differences in length in Group 1 and Group 2 were mainly due to the femur. Mean extremity length difference of patients in the closed reduction group was close to the difference seen in the normal population. In the group with medial open reduction, a greater difference was found and this difference was statistically significant when compared regarding leg length discrepancy in patients in Group 1 and Group 2. **Discussion:** In our study, we noticed that in most of our patients, leg length difference was not clinically significant, but in some patients, this difference was approximately two cm. Therefore, we recommend that the patients especially undergoing medial open reduction should be followed for leg length inequality until their skeletal maturity is reached.

Keywords

Leg Length Inequality; Hip Dislocation; Congenital

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Introduction

Developmental dysplasia of the hip (DDH) is a congenital defect of the skeleton including acetabular dysplasia, subluxation, and complete dislocation of the femoral head [1]. The most appropriate treatment option in a case of failed closed reduction or requirement for forcing positions to ensure the reduction in DDH is an open reduction [2]. The medial approach open reduction for DDH was first described by Ludloff nearly 100 years ago. Later, modifications of this technique were done by Ferguson and Weinstein-Ponseti [3]. Although the medial approach open reduction has advantages of low redislocation rates, not damaging hip abductors and iliac epiphysis, and having a small scar, it also has disadvantages such as narrow surgical field, non-availability of additional surgical procedures such as capsulorrhaphy or pelvic osteotomy [2]. Despite successful results with this technique, there is still no consensus in the literature regarding its safety and efficacy [4]. Complications such as avascular necrosis (AVN) and residual subluxation or redislocation have been reported after both closed and open reduction [5,6]. Except for the studies conducted by Metcalfe [7] and Zhang [8], there is very little information in the literature regarding leg length discrepancy (LLD) in patients with unilateral DDH. The aim of our study is to both identify and compare characteristics of LLD in unilateral DDH patients treated with closed reduction and medial open reduction.

Material and Method

Clinical and radiographic data of 108 patients with unilateral DDH were evaluated retrospectively. Patients with closed reduction (Group 1) and medial open reduction (Group 2) were grouped into two different groups. Patients with missing clinical and radiological data (8 patients), cerebral palsy (4 patients), myelomeningocele (2 patients), arthrogyrosis multiplex congenita (1 patient), clubfoot (3 patients), redislocation (2 patients), pelvic and femoral osteotomy (10 patients), femur head deformity (4 patients), flexor contracture in the hip and knee (1 patient) were excluded from the study. Thus, 31 patients (42.5%) were included in Group 1, and 42 patients (57.5%) were included in Group 2. The mean age of patients at the time of treatment in Group 1 was 9.9 ± 4.5 months, and the mean follow-up was 76.3 ± 29.7 months. The mean age of the patients at the time of treatment in Group 2 was 12.8 ± 5.5 months, and the mean follow-up was 69.8 ± 25.3 months.

Patients in the first group did not undergo skeletal traction before closed reduction. Closed reduction was performed under general anaesthesia. The hip was reduced to avoid forced manoeuvres and then brought into adduction until dislocated. Next, the hip was reduced again and brought to the extension until dislocated. In addition, the amount of internal rotation required to provide reduction was also determined. The hip was assessed as stable if it preserved the reduction in the safe zone described by Ramsey [9]. Reduction was thought to be unstable if excessive abduction ($>60^\circ$) or internal rotation greater than 10° – 15° was required for continued reduction. Adductor tenotomy can be performed to increase the safe zone by increasing the abduction range. Adductor tenotomy was performed in 10 patients (23.8%) who underwent closed reduction. Concentric reduction was confirmed by C-arm

fluoroscopy, followed by a hip spica cast that was applied with 40° – 45° of abduction and 95° of flexion as described by Kumar [10]. The cast was renewed under general anaesthesia 45 days after surgery and was completely removed at 90 days. The abduction night splint was used for 2 more months.

A medial approach open reduction was performed in hips that could not be reduced closely, or that could be reduced by forcing positions ($>90^\circ$ – 100° of flexion or $>60^\circ$ of abduction). With the hip flexed and abducted, a 3–4 cm transverse incision was made over the groin area, and an adductor longus tenotomy was performed. By using the interval between adductor brevis and the pectineus, the iliopsoas tendon was divided from its insertion site on the lesser trochanter. The medial femoral circumflex vessels were identified and secured. Following the opening of the capsule with a “T-shaped” incision, both the ligamentum teres and the transverse ligament were incised, and the pulvinar was removed. Concentric reduction of the femoral head was then performed. The capsule was left open, and the skin was closed. A hip spica cast was applied with 45° of abduction and 90° of flexion. The cast was renewed under general anaesthesia 45 days after surgery and was completely removed at 90 days. The abduction night splint was used for 2 more months.

Radiography scans were obtained by a computed radiography method to assess radiological parameters of patients during the final examination [11]. The pelvis and all parts of both lower extremities were visualised with these radiographs obtained while the patient stood facing the x-ray tube, and the film-focus distance was 203 cm. Each leg was internally rotated to ensure that the patella pointed anteriorly [11]. Radiographs were viewed and measured on a picture archiving and communication system (Enlil PACS Viewer, Eskisehir, Turkey). When measuring the length of the femur, the distance between the uppermost end of the femoral head and the midpoint of the line tangent to the medial and lateral femoral condyles was measured. While measuring the length of the tibia, the distance between the tibial intercondylar eminence and the middle point of the tibial plafond was measured. When measuring the total length of the lower limb, the distance between the uppermost point of the femoral head and the middle point of the tibial plafond was measured [8]. Both lower extremity lengths were measured with this method and values were recorded (Figure 1, 2). To minimise measurement errors, all measurements were initially made by two different trained orthopaedic surgery residents, and the second measuring orthopaedist did not know the initially measured values. Averages of obtained values were determined, and measurements were completed. We required a cut-off value to know whether the extremity had a different length. The literature review we have conducted for this purpose has found that the mean value of 5 mm is used as the threshold value in similar studies [12,13]. Therefore, we considered 5 mm as the cut-off value in our study.

The clinical assessment of patients was performed using McKay, and the radiologic evaluation was based on the Severin classification [14,15].

Statistical analysis

Data analysis was performed using Statistical Package for the



Figure 1. (a) Preoperative anteroposterior pelvic view of the 6-month old patient (b) A full-length standing AP computed radiograph of the same child 8 years after closed reduction. Left femur 8 mm longer than the right femur.



Figure 2. (a) Preoperative anteroposterior pelvic view of the 17-month old patient (b) A full-length standing AP computed radiograph of the same child 4 years after medial open reduction. Left femur 15 mm longer than the right femur.

Social Sciences version 22.0. The distribution of continuous variables was determined by Kolmogorov-Smirnov and Shapiro-Wilk normality tests. Quantitative and qualitative data were expressed as mean ± standard deviation and percentage, respectively. In addition, data that were not normally distributed were expressed as median (minimum-maximum). The Mann-Whitney U test was used for the comparison of two groups that were not normally distributed. The Chi-Square test was used for comparison of qualitative data. The Spearman correlation test was used for correlation of parameters that were not normally distributed. The Wilcoxon signed ranks test was used to compare dependent variables that were not normally distributed. A p-value of less than .05 was considered statistically significant.

Institutional review board statement: The study was approved by our institutional ethics committee review board (29.9.2016/14/16).

Results

Patients in Group 1 and Group 2 were similar regarding gender, follow-up, and baseline dislocation grade, but Group 1 patients were younger (Table 1).

At the final follow-up, all patients had satisfactory functional results, were free of pain, and walked without a limp. Similarly, good radiological results were obtained in all patients. Both groups had similar clinical and radiological findings (Table 2).

In Group 1, 16 patients (51.6%) had a longer ipsilateral femur than the femur on the contralateral side, mean 4.25 ± 1.43 mm (range, 2 to 6 mm) and 15 patients (48.4%) had a shorter femur than the femur on the contralateral side, mean 2.20 ± 0.86 mm (range, 1 to 4 mm). The number of patients with a length difference of 5 mm or more was 7 (22.6%). This difference was not statistically significant when compared with the contralateral side ($p = .103$). Eighteen patients (58.1%) had a longer ipsilateral tibia than the tibia on the contralateral side, mean 1.28 ± 0.57 mm (range, 1 to 3 mm) and 13 patients (41.9%) had a shorter ipsilateral tibia than the tibia on the contralateral side, mean 1.23 ± 0.43 mm (range, 1 to 2 mm). This difference was not statistically significant when compared with the contralateral side ($p = .224$). Seventeen patients (54.8%) had a longer ipsilateral leg length than the leg length on the contralateral side, mean 4.71 ± 0.45 mm (range, 1 to 8 mm) and 14 patients (45.2%) had a shorter leg length than the leg length on the contralateral side, mean 2.93 ± 0.42 mm (range, 1 to 6 mm). The number of patients with a length difference of 5 mm or more was 8 (25.8%), and this difference was not statistically significant when compared with the contralateral side ($p = .094$).

In Group 2, 32 patients (76.2%) had a longer ipsilateral femur than the femur on the contralateral side, mean 8.59 ± 4.31 mm (range, 3 to 19 mm) and 10 patients (23.8%) had a shorter femur than the femur on the contralateral side, mean 2.9 ± 1.10 mm (range, 1 to 5 mm). The number of patients with a length difference of 5 mm or more was 27 (64.3%), and this difference was statistically significant when compared with the contralateral side ($p < .001$). Thirty-one patients (58.1%) had a longer ipsilateral tibia than the tibia on the contralateral side, mean 1.72 ± 0.72 mm (range, 1 to 3 mm) and 11 patients (26.2%) had a shorter ipsilateral tibia than the tibia on the contralateral side, 1.30 ± 0.48 mm (range, 1 to 2 mm). This difference was not statistically significant when compared with

Table 1. Comparison of general characteristics between Groups 1 and 2

	Group 1	Group 2	p-value
Age * (month)	11.0 (3-20)	13.5 (3-23)	0.019
Female / Male †	29 (93.5) / 2 (6.5)	35 (83.3) / 7 (16.7)	0.189
Left / Right †	18 (58.1) / 13 (41.9)	23 (54.8) / 19 (45.2)	0.779
Follow-up * (month)	62 (30-132)	67.5 (24-156)	0.339
Tönnis Grade II †	11 (35.5)	21 (50.0)	0.204
Tönnis Grade III	16 (51.6)	13 (31.0)	
Tönnis Grade IV	4 (12.9)	8 (19.0)	

*Values are given as the median (range). † Values are given as the number (%).

Table 2. Comparison of clinical and radiological results between Group 1 and Group 2.

		Group 1	Group 2	p-value
McKay	Excellent	26 (83.9)	27 (64.3)	0.064
	Good	5 (16.1)	15 (35.7)	
Severin	Class I	21 (67.7)	18 (46.2)	0.062
	Class II	10 (32.3)	24 (57.1)	

the contralateral side ($p = .010$). Thirty-two patients (76.2%) had a longer ipsilateral leg length than the leg length on the contralateral side, mean 10.25 ± 0.82 mm (range, 4 to 20 mm) and 10 patients (23.8%) had a shorter leg length than the leg length on the contralateral side, mean 3.60 ± 0.61 mm (range, 1 to 6 mm). The number of patients with a length difference of 5 mm or more was 30 (71.4%), and this difference was statistically significant when compared with the contralateral side ($p < .001$).

Obtained results showed that both length differences in Group 1 and Group 2 were mainly due to the femur. This difference was statistically significant when compared regarding LLD in patients in Group 1 and Group 2 ($p < .001$). There was no statistically significant difference between low dislocations (Tönnis Type 2) and high dislocations (Tönnis Types 3 and 4) when the relation between initial dislocation grades and LLD of patients in Group 1 and Group 2 was evaluated ($p = .563$).

Discussion

Providing concentric reduction without impairing the circulation to the femoral head at the earliest possible time is the primary purpose of DDH treatment. Remodelling of both the femoral head and the acetabulum can be achieved by reduction at early ages. Closed reduction is the first treatment option for patients who failed the Pavlik bandage. Closed reduction includes an examination under anaesthesia, arthrography, if necessary adductor tenotomy and immobilisation of the affected hip in the appropriate position after reduction [16].

Open reduction can be performed in case of failed closed reduction or requirement for forcing positions to ensure the reduction. The medial approach, which was defined by Ludloff for open reduction of dysplastic hips, is simple, safe, atraumatic due to minimal tissue dissection and does not require a blood transfusion [17].

Complications such as residual dysplasia, redislocation and AVN (0% to 67%) may be encountered, although both closed reduction and medial open reduction have high success rates [16,18]. Another complication seen in patients with DDH is LLD [7,8]. LLD can be observed in children undergoing both femoral and acetabular surgery. However, femoral overgrowth can also be observed in adults with dysplastic acetabulum treated with non-surgical methods [7]. In this study, patients with unilateral DDH who underwent closed reduction and medial open reduction were compared regarding LLD. Sixteen patients (51.6%) in Group 1 had a longer ipsilateral femur than the femur on the contralateral side, and this was due to the femur. In patients with DDH, the LLD is higher than in the normal population and is thought to originate from an anomalous biological factor, but the actual cause is not fully known [7]. However, Soukka et al. [19] measured the extremity length of 247 healthy participants in their study and found a mean difference of 5.5 ± 4.1 mm (the majority being between 0 and 5 mm). In our study, mean extremity length difference of patients in the closed reduction group was close to the difference seen in the normal population. In the group with medial open reduction, a greater difference was found on the affected side than in the normal population. Our hypothesis is that a similar situation causes femoral overgrowth following paediatric femur fractures can cause this

overgrowth. Femoral overgrowth after a fracture occurs as a result of stimulation of the growth plate in children [20]. There are different opinions regarding the situation that causes this stimulation, as to whether it is a compensatory mechanism to balance extremity lengths or a physiological response to trauma [21]. Although minimal tissue dissection is performed during medial approach open reduction, the proximal femoral growth plate may have been stimulated as a response to trauma caused by tenotomy, opening of the capsule, excision of both the pulvinar and the ligamentum teres. There is no rule that femoral overgrowth will be observed in all patients with femoral fractures [21]. Similarly, we detected femoral overgrowth of ≥ 5 mm in about 2/3 of our patients who had undergone medial approach open reduction.

There was no statistically significant difference between the two groups regarding clinical and functional outcomes. However, when we looked at leg lengths, the femoral overgrowth in the open reduction group was greater, and this difference was statistically significant.

When the relationship between leg length amounts in both groups and the severity of dislocation at baseline was investigated, there was no statistically significant difference between the two groups. Zhang et al. [8] assessed LLD in a total of 67 adult patients with unilateral DDH and found no significant association between baseline dislocation grade and LLD. In our study, LLD was due to the femur. In contrast, Zhang et al. [8] emphasised that LLD originate more in the tibia in their study [8]. The reason for this is that all of the patients in Zhang's study are adults with dislocated hips [8]. Sugano et al. [22] stressed that both femur head diameter and femur neck length decrease in dislocated hips. As a result, the femoral length decreases in dislocated hips. However, the normal concordance between the acetabulum and the femoral head also leads to the development of the femoral head [23,24].

Our study has some limitations, such as the relatively low number of patients in each group, the presence of both measurement-based study and individual differences in measurements and the absence of long-term outcomes.

Despite the aforementioned limitations of our study, we did not find a comparison of LLD after closed and open reduction in the published literature. We think that our study can contribute to the literature in this respect. In our study, we noticed that in most of our patients, leg length difference was not clinically significant, but in some patients, this difference was approximately two cm. Therefore, we recommend that patients especially undergoing medial open reduction should be followed for leg length inequality until their skeletal maturity is reached.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national re-

search committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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